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Plant Density and Cover Response to Several Seeding Techniques Following Wildfire

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ABSTRACT

Comparisons of several seeding techniques were made following two wildfires in central Utah. In instances where two seeding techniques could be directly compared on the same site, the most intensive seeding technique always resulted in greater density and cover of seeded grasses. In the specific comparisons, aerial seeding and multiple chaining were better than aerial seeding alone, drilling was better than aerial seeding and chaining, and land imprinting was better than drilling. Because conditions on the burned area were heterogenous, many of the specific individual revegetation attempts could not be directly compared. However, generally, similar conclusions can be drawn as in the paired seeding comparisons. On the average, double chaining resulted in better stands than single chaining, and drilling resulted in better stands than chaining, although initial seeding conditions and later wind erosion caused variable results

KEYWORDS: revegetation, rangeland drill, land imprinter, chaining, aerial seeding

Rehabilitation of rangelands by seeding began in the Western United States in the late 1800's. More literature exists on range seeding than any other practice in range management (Heady 1975). However, only a limited amount of seeding information in the pinyon-juniper and sagebrush zones has been published in recent years. Most of that published addresses forage species adaptation rather than the issue of seeding techniques (Lavin and Johnsen 1975, 1977a, 1977b; Stevens 1983). Lavin and others (1973) discussed intensive revegetation techniques such as prespraying, spraying, undercutting, plowing, surface drilling, and furrow drilling, but they did not study the effectiveness of less intensive techniques such as broadcast seeding with chaining, cabling or railing, or broadcast seeding alone. Their work showed that different combinations of season, seedbed preparation, and planting procedure are required for best results with different plant species.

Several reports have suggested that seeding effectiveness was less with chaining than with drilling, but direct comparisons were not made (Ralphs and Busby 1978, 1979). Successful broadcast seeding appears to be most likely when precipitation is above normal and the soils are rocky (Davis 1986; Koniak 1983). Recent information on the relative effectiveness of the land imprinter versus the rangeland drill suggests the imprinter is more successful than the drill on loose seedbeds but less successful on firm seedbeds (Haferkamp and others 1985).

STUDY AREA

In July 1981 lightning ignited two major fires in the Canyon Mountains area of central Utah (fig. 1). These fires, the Clay Springs and Little Oak Creek Burns, covered over 25,000 ha in the pinyon-juniper (*Pinus* spp.-*Juniperus* spp.) and big sagebrush (*Artemisia tridentata*) vegetation types. The lands burned were predominately under Federal management—Forest Service of the U.S. Department of Agriculture and Bureau of Land Management (BLM) of the U.S. Department of the Interior.

The soils on most of the burned area were formed on alluvium from sandstone, limestone, quartzite, and igneous rocks. They varied from shallow to deep, and many had a surface soil texture of fine sandy loam. In the valley bottoms, where the prefire vegetation had been dominated by big sagebrush, the destruction of organic material by the fire was virtually complete, resulting in removal of all competing plants and debris from the soil surface. This left the soils vulnerable to wind erosion.

Revegetation efforts by the management agencies began in the fall of 1981. A variety of techniques were used depending upon site conditions, agency approach, and some special study situations. The techniques included aerial seeding, aerial seeding with single chaining, aerial seeding with double chaining (usually with a modified chain), a special case of aerial seeding with a strip of multiple chaining, rangeland drilling, and land imprinting.

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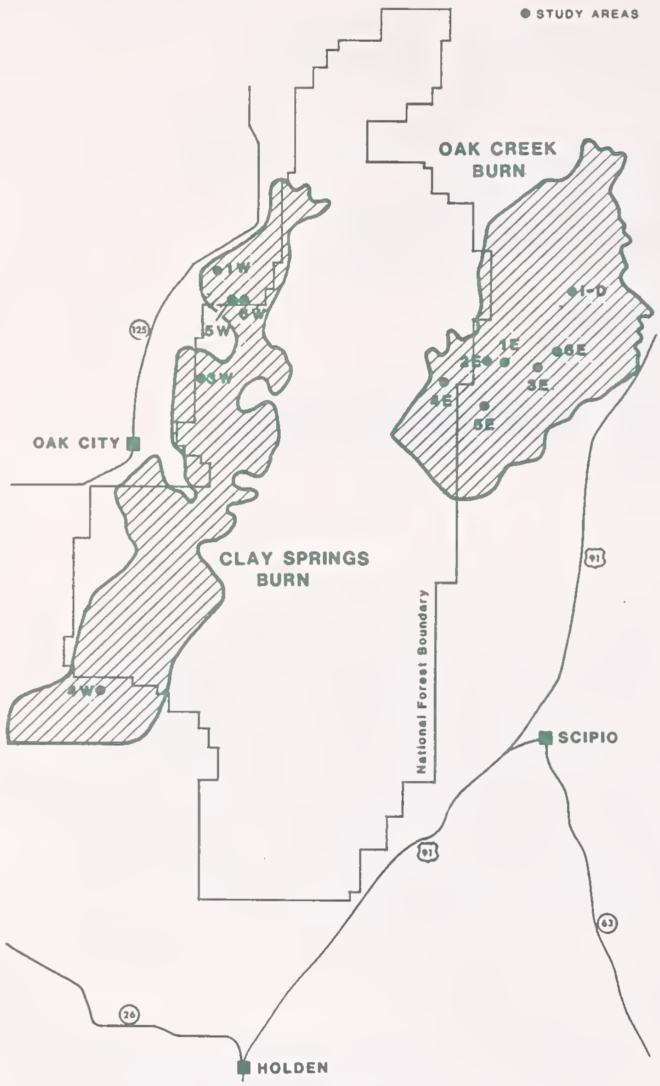

Figure 1—Location of the Canyon Mountains burns and study sites.

The implement used for imprinting was described by Johnson (1982). It included a seed box mounted to drop seed ahead of the rollers.

On the National Forest System lands, seeding was from the air at a rate of 11.3 kg/ha,which included these species (see table 1 in "Results" section for scientific names): crested wheatgrass, 3.4 kg; intermediate wheatgrass, 1.7 kg; Russian wildrye, 1.7 kg; 'Manchar' smooth brome, 1.1 kg; 'Ladak' alfalfa, 2.0 kg; small burnet, 1.1 kg; and yellow sweetclover, 0.3 kg. On areas revegetated by the BLM at the rate of 9.0 kg/ha, the amounts per seeded species were: Fairway crested wheatgrass, 4.5 kg; 'Luna' pubescent wheatgrass, 1.7 kg; Russian wildrye, 2.2 kg; and 'Ladak' alfalfa, 0.6 kg.

On BLM lands most seeding was done by drilling, although some areas were seeded from the air. In addition to the seed mix, 0.6 kg/ha of fourwing saltbush seed was applied from the air across the BLM seeding area. In several drilled locations severe wind erosion occurred due to high wind velocity, light-textured soils, and lack of cover. These areas were redrilled in 1982 with 12.2 kg/ha using the following seed mixture: crested wheatgrass, 4.5 kg; 'Luna' pubescent wheatgrass, 2.2 kg; fourwing saltbush, 1.1 kg; winter rye, 2.2 kg; yellow sweetclover, 1.1 kg; and 'Ladak' alfalfa, 1.1 kg.

Mean annual precipitation ranges from 250 to 410 mm depending upon site elevation. Precipitation for the three water-years following seeding was 160 to 172 percent of normal, based on weather records from nearby communities of Scipio and Oak City. However, rainfall the first year after seeding (1982) was only 68 percent of normal for the important April to June period. Conversely, in 1983, when a portion of the area was redrilled, the April to June precipitation was 151 percent of normal, and in 1984, when the study data were collected, rainfall for the same months was 180 percent of normal.

SAMPLING METHODS

Individual study sites were sampled by 20 to 90 transects each. The transects consisted of 10 plots of $1m^2$ each, located 3 m apart. Plant density counts were recorded for all perennial plant species within the $1\text{-}m^2$ plots. Estimates of lightly compressed foliage cover (proportion of area completely covered by foliage in a manner similar to the square-foot-density method; Brown 1954) were made for all species using the following percentage categories: 0.01 to 1.0, 1.1 to 5.0, 5.1 to 25.0, 25.1 to 50.0, 50.1 to 75.0, 75.1 to 95.0, and 95.1 to 100. Standing crop biomass was also determined and reported in Clary (1987) and Clary and Wagstaff (1987). Where paired comparisons were possible, statistical analyses were conducted by t-test.

RESULTS

The plant communities present 3 years after the fires and seeding were about 80 percent grasses (table 1). On the Clay Springs Burn, a seeded perennial grass, crested wheatgrass, was the most prominent in the amount of cover while the annual cheatgrass was second. On the Little Oak Creek Burn, three perennial grasses—the seeded crested wheatgrass and intermediate wheatgrass, and the native bluebunch wheatgrass—each had greater amounts of cover than did cheatgrass. Forb composition was dominated by the seeded alfalfa and was approximately 10 percent of the plant community. The most abundant shrub on the Clay Springs Burn was broom snakeweed, while Gambel oak exceeded broom snakeweed on the Little Oak Creek Burn.

Table 1—Average plant density (number/m^2) and cover (percent) 3 years after seeding two wildfire burns

Species	Clay Springs		Little Oak Creek	
	Density	Cover	Density	Cover
GRASSES				
Crested wheatgrass (*Agropyron cristatum* and *A. desertorum*)	3.28	2.66	2.75	2.70
Thickspike wheatgrass (*Agropyron dasystachyum*)	.52	.01	.00	.00
Intermediate wheatgrass (*Agropyron intermedium*)	.96	.67	1.57	1.46
Western wheatgrass (*Agropyron smithii*)	.05	T[1]	2.03	.26
Bluebunch wheatgrass (*Agropyron spicatum*)	.08	.07	1.45	1.92
Pubescent wheatgrass (*Agropyron trichophorum*)	.10	.08	.43	.46
Smooth brome (*Bromus inermis*)	.74	.40	.02	.01
Cheatgrass (*Bromus tectorum*)	—[2]	1.68	—	1.43
Russian wildrye (*Elymus junceus*)	.03	.01	.07	.05
Indian ricegrass (*Oryzopsis hymenoides*)	T	T	.12	.07
Switchgrass (*Panicum virgatum*)	T	.01	.00	.00
Bluegrass (*Poa* spp.)	.00	.00	.01	T
Sandberg bluegrass (*Poa secunda*)	.14	.01	.23	.04
Winter rye (*Secale cereale*)	—	.00	—	.00
Bottlebrush squirreltail (*Sitanion hystrix*)	.03	.02	.16	.13
Needleandthread (*Stipa comata*)	.00	.00	.03	.01
FORBS				
Pale agoseris (*Agoseris glauca*)	.00	.00	.01	T
Kings sandwort (*Arenaria kingii*)	.00	.00	.03	.01
Eureka milkvetch (*Astragalus eurekensis*)	.00	.00	.12	.03
Bastard toadflax (*Comandra pallida*)	.00	.00	.01	.03
Hairy fleabane (*Erigeron aphanactis*)	.00	.00	.07	.01
Redroot eriogonum (*Eriogonum racemosum*)	.00	.00	.10	.02
Alfileria (*Erodium cicutarium*)	—	T	—	.04
Prickly lettuce (*Lactuca serriola*)	—	.08	—	.01
FORBS (Con.)				
Peavine (*Lathyrus brachycalyx*)	.00	T	T	.01
Heath aster (*Leucelene ericoides*)	.00	.00	.13	.07
Alfalfa (*Medicago sativa*)	.50	.61	.35	.76
Yellow sweetclover (*Melilotus officinalis*)	.00	.00	.00	.00
Rock goldenrod (*Petradoria pumila*)	.00	.00	.03	.01
Hood phlox (*Phlox hoodii*)	.00	.00	.00	.04
Russian-thistle (*Salsola iberica*)	—	.00	—	.06
Small burnet (*Sanguisorba minor*)	T	T	.01	T
Tumblemustard (*Sisymbrium altissimum*)	—	.01	—	T
Gooseberryleaf globemallow (*Sphaeralcea grossulariaefolia*)	.05	.02	.37	.04
SHRUBS				
Louisiana sagewort (*Artemisia ludoviciana*)	.00	.00	.06	.01
Big sagebrush (*Artemisia tridentata*)	.01	.02	.02	.01
Fourwing saltbush (*Atriplex canescens*)	.00	.00	.00	.00
Downy rabbitbrush (*Chrysothamnus viscidiflorus puberulus*)	.01	.02	.01	.01
Variedleaf green rabbitbrush (*Chrysothamnus viscidiflorus viscidiflorus*)	.00	.00	.01	.02
Stansbury cliffrose (*Cowania mexicana stansburiana*)	T	.04	.00	.00
Nevada ephedra (*Ephedra nevadensis*)	.01	.02	.01	.02
Utah juniper (*Juniperus osteosperma*)	T	.02	.00	.00
Pricklypear (*Opuntia* spp.)	T	.02	.02	.03
Gambel oak (*Quercus gambelii*)	.00	.00	.01	.21
Horsebrush (*Tetradymia* spp.)	.00	.00	.01	.03
Broom snakeweed (*Gutierrezia sarothrae*)	.51	1.04	.20	.16
ALL SPECIES	7.02	7.52	10.45	10.18

[1]T = trace.
[2]— = no density data for annuals.

The revegetation efforts obviously resulted in plant establishment because the herbaceous portion of the plant community was dominated by seeded plants. However, different degrees of success occurred as a result of different seeding techniques.

Perennial Plant Density

Paired revegetation treatments were compared on similar sites in three instances. Chaining following aerial seeding was more successful in establishment of seeded grasses than aerial seeding alone, drilling was more successful than chaining, and imprinting was more successful than drilling (table 2). Seeded forb densities were also greater in two of these same three treatments. No successful establishment of shrubs was detected. Native plant densities were highly variable between and within treatments and showed no significant trends. Combined densities of all perennial plants, seeded and native, were significantly higher in the more successful revegetation treatments. Therefore, increases in seeded species did not result in equivalent decreases in native perennial species.

On much of the burn where paired comparisons were not feasible, a similar trend was apparent, that is, the more intensive the planting effort the better the result. Drilling treatments were better than the chaining treatments for average establishment of seeded species on the Little Oak Creek Burn (table 3). Double chaining after aerial seeding resulted in higher seeded grass densities than did single chaining on the Clay Springs Burn although there was little difference in seeded forb densities (table 4). The variations in native plant densities appeared to be a function of their presence before the fire rather than a response to a specific revegetation effort.

Plant Cover

The cover of seeded grasses, as with plant densities, was greater for those treatments that tend to provide better seed coverage or seedbed compaction (table 5). Chaining after aerial seeding was better than aerial seeding alone, drilling was better than chaining, and land imprinting was better than drilling. A similar trend occurred for seeded forbs, but the difference was statistically significant in only one of the three comparisons. In all three comparisons, the cover of annuals was significantly higher in the less successful seeding treatments, undoubtedly the result of less competition from the seeded grasses. There did not appear to be an important variation in total plant cover within paired treatments, although one significant difference did occur.

On the unpaired sites of the Little Oak Creek Burn, the single drilled site exhibited about twice the cover and the redrilled site about 11 times the cover of seeded plants as did the chained sites (table 6). Similar to the paired treatments (above), the cover of annuals was greater where there was less establishment of seeded grasses. Little difference in total plant cover occurred among treatments. Fewer differences were present among the unpaired sites on the Clay Springs Burn compared to sites on the Little Oak Creek Burn. One double-chained site had greater

Table 2—Comparisons of perennial plant densities (number/m^2) on the Canyon Mountains burns

Plant group	Aerial seed and multiple chain vs. aerial seed (5W,6W)	Drill vs. aerial seed and single chain (1E,2E)	Imprint vs. drill (I-D)[1]
Seeded			
Grass	9.2a vs. 0.5b[2]	6.7a vs. 1.6b	4.7a vs. 2.1b
Forb	1.2a vs. .0b	.7a vs. .2a	.1a vs. .0b
Shrub	.0a vs. .0a	.0a vs. .0a	.0a vs. .0a
Native			
Grass	.2a vs. .1a	5.1a vs. 5.7a	9.5a vs. 6.5a
Forb	.1a vs. .0a	1.7a vs. 2.9a	.0a vs. .0a
Shrub	.4a vs. 1.4a	.3a vs. .4a	.0a vs. .0a
Total	11.1a vs. 2.0b	14.5a vs.10.8b	14.3a vs. 8.6b

[1]Data from Clary (1987).
[2]Data pairs within columns followed by different letters are significantly different at the 5 percent level.

Table 3—Perennial plant densities (number/m^2, $x \pm se$) on individual locations, Little Oak Creek Burn

Plant group	Drill (3E)	Drill redrill 1982 (6E)	Aerial seed and double chain (4E)	Aerial seed and single chain (5E)
Seeded				
Grass	5.4 ± 0.8	14.4 ± 1.1	1.9 ± 0.4	1.4 ± 0.7
Forb	.6 ± .1	1.1 ± .1	.0 ± .0	.0 ± .0
Shrub	.0 ± .0	.0 ± .0	.0 ± .0	.0 ± .0
Native				
Grass	.2 ± .1	1.4 ± 1.3	3.2 ± .4	1.0 ± .2
Forb	.5 ± .3	.0 ± .0	.4 ± .2	.1 ± .1
Shrub	.1 ± .1	.0 ± .0	1.1 ± .4	.8 ± .1
Total	6.8 ± 1.0	16.9 ± 1.7	6.6 ± .6	3.3 ± .7

Table 4—Perennial plant densities (number/m^2, $x \pm se$) on individual locations, Clay Springs Burn

Plant group	Aerial seed and double chain (4W)	Aerial seed and double chain (3W)	Aerial seed and single chain (1W)
Seeded			
Grass	6.6 ± 1.0	5.4 ± 0.8	3.7 ± 0.5
Forb	.1 ± .1	.3 ± .1	.9 ± .2
Shrub	.0 ± .0	.0 ± .0	.0 ± .0
Native			
Grass	2.9 ± 1.6	.4 ± .1	.6 ± .2
Forb	.0 ± .0	.0 ± .0	.1 ± .1
Shrub	.2 ± .1	1.0 ± .4	.1 ± .1
Total	9.8 ± 1.6	7.1 ± .7	5.4 ± .7

Table 5—Comparisons of compressed plant cover (percent) on the Canyon Mountains burns

Plant group	Aerial seed and multiple chain vs. aerial seed (5W,6W)	Drill vs. aerial seed and single chain (1E,2E)	Imprint vs. drill (I-D)[1]
Perennial			
Seeded			
Grass	4.2a vs. 0.2b[2]	2.7a vs. 0.6b	9.4a vs. 5.0b
Forb	1.0a vs. .0a	.9a vs. .1a	.5a vs. .2b
Shrub	.0a vs. .0a	.0a vs. .0a	.0a vs. .0a
Native			
Grass	.0a vs. .0a	5.9a vs. 5.5a	1.7a vs. 1.4a
Forb	.0a vs. .0a	.2a vs. .6b	.0a vs. .0a
Shrub	.6a vs. 3.0a	.2a vs. .3a	.0a vs. .0a
Annual	.1a vs. 1.4b	1.1a vs. 2.2b	.1a vs. .7b
Total	5.9a vs. 4.6a	11.0a vs. 9.3a	11.7a vs. 7.3b

[1]Data from Clary (1987).
[2]Data pairs within columns followed by different letters are significantly different at the 5 percent level.

Table 6—Compressed plant cover (percent, $x \pm$se) on individual locations, Little Oak Creek Burn

Plant group	Drill (3E)	Drill redrill 1982 (6E)	Aerial seed and double chain (4E)	Aerial seed and single chain (5E)
Perennial				
Seeded				
Grass	5.5 ± 1.0	11.7 ± 1.1	1.6 ± 0.5	0.8 ± 0.5
Forb	2.2 ± .5	2.1 ± .4	.0 ± .0	.0 ± .0
Shrub	.0 ± .0	.0 ± .0	.0 ± .0	.0 ± .0
Native				
Grass	.1 ± .1	.2 ± .2	4.1 ± .7	.5 ± .3
Forb	.0 ± .0	.0 ± .0	.2 ± .1	.0 ± .0
Shrub	.0 ± .0	.0 ± .0	2.6 ± 1.2	.9 ± .2
Annual	.6 ± .2	.0 ± .0	2.7 ± .7	6.1 ± 1.2
Total	8.4 ± 1.0	14.0 ± 1.2	11.2 ± 1.0	8.3 ± 1.0

cover of seeded grasses and less of annuals than the single-chained site, but the second double-chained site was comparable to the single-chained site (table 7). Total plant cover was similar among sites.

Table 7—Compressed plant cover (percent, $x \pm$se) on individual locations, Clay Springs Burn

Plant group	Aerial seed and double chain (4W)	Aerial seed and double chain (3W)	Aerial seed and single chain (1W)
Perennial			
Seeded			
Grass	7.4 ± 1.2	3.8 ± 0.8	3.6 ± 0.5
Forb	.2 ± .1	.3 ± .1	1.6 ± .3
Shrub	.0 ± .0	.0 ± .0	.0 ± .0
Native			
Grass	.1 ± .1	.1 ± .1	.3 ± .1
Forb	.0 ± .0	.0 ± .0	.1 ± .0
Shrub	.5 ± .3	1.4 ± .5	.3 ± .2
Annual	1.0 ± .4	2.5 ± .9	3.9 ± 1.4
Total	9.2 ± 1.1	8.1 ± .8	9.8 ± 1.2

DISCUSSION

Paired and unpaired comparisons between revegetation techniques generally indicated greater densities and cover of seeded plants for those revegetation practices that appeared to do a better job of seed coverage or compaction of the seedbed. This is consistent with past results (Jordan n.d.; Plummer and others 1968; Reynolds and Springfield 1953). Direct comparisons of revegetation techniques across all sites could not be made because site and situation differences were involved. For example, aerial seeding-chaining was often applied to steeper and rockier terrain with higher precipitation than was drilling or imprinting. However, in instances when drilling could be directly or indirectly compared to aerial seeding-chaining on similar sites, drilling resulted in superior stands of seeded species.

In the paired comparisons, treatments resulting in the most seeded grasses also resulted in the least annual grasses. This same trend continued through the unpaired sites. However, the presence of seeded grasses did not significantly decrease the density or cover of native perennial grasses on the paired sites, nor did the seeded grasses appear to have an effect on native perennials when viewed across the unpaired sites. Three years after the fire and the seeding effort, the amount of native perennial grasses present seemed to be primarily a function of what was present before the fire. The presence of seeded species occurred mainly at the expense of annual grasses.

The side-by-side comparison of land imprinting and rangeland drilling illustrated an approximately 2:1 advantage of density and cover of seeded species in favor of imprinting under the conditions of this study. The increased establishment of seeded species with the imprinter probably resulted in part from increased surface soil bulk density and the seed being pressed into close contact with the light-textured soil (Anderson 1981). The ratio of comparative seeding costs is \$67 (imprinting): \$42 (drilling) (Clary and Wagstaff 1987), which suggests that the imprinter established 25 percent more seeded plant density and cover per dollar of cost than did the drill. However, studies of herbage production on these burns showed that compensatory growth in the thinner stands of the drilling resulted in similar amounts of biomass being produced 3 years after seeding. In the case of herbage production the drilling was more efficient per dollar of cost (Clary and Wagstaff 1987).

Because costs of aerial seeding and chaining combined equaled or exceeded those of drilling or imprinting (Clary and Wagstaff 1987) and the plant establishment success was less, there appears to be little cost-efficiency justification for use of the chaining technique on sites that can be drilled or imprinted. For sites where drilling or imprinting techniques cannot be applied, careful consideration should be given to seeding expenditures. Under many conditions the success of plant establishment using the chaining technique may be too low to justify its use. Presumably, to justify the chaining technique even modest revegetation success is needed for such values as soil protection, wildlife habitat characteristics, preclusion of unwanted plants, or enhancement of visual quality (Clary and Wagstaff 1987).

In some instances where substantial amounts of native perennial grasses are present, such as occurred on study areas 1E, 2E, and 4E, there may be little necessity to incur seeding costs. Natural recovery of native perennials should provide an adequate forage resource and soil protection (West and Hassan 1985). Unfortunately, it is often difficult to predict postfire response on many sites.

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